*Proceedings of the 5th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), 7~9 February 2020, KUET, Khulna, Bangladesh (ISBN-978-984-34-8764-3)*

# MUNICIPAL WASTEWATER TREATMENT USING NATURAL ADSORBENT IN RAJSHAHI CITY CORPORATION

**Md. Zahid hassan*[1], Anupam Chowdhury[2] and Md. Kumruzzaman[3]**

[1]*Student, Rajshahi University of Engineering & Technology, Bangladesh, e-mail:www.nirobjahid@gmail.com*
[2]*Assistant Professor, Rajshahi University of Engineering & Technology, Bangladesh,e-mail: anupam.19ce@gmail.com*
[3]*Professor, Rajshahi University of Engineering & Technology, Bangladesh, e-mail: kzzaman2001@hotmail.com*

***Corresponding Author**

## ABSTRACT

Water is one of the most important components involved in the creation and development of healthy life. As the demand for safe water is increased but the water resources are limited, there is a growing awareness to treat the wastewater and make more efficient use of the wastewater. The conventional methods for treating wastewater are expensive. Consequently, the search for contrarily but effective, efficient and economic methods has been prime concern in recent times. Thus, the use of biomaterials, such as agricultural waste as adsorbents for organic and metal ions is being exploited due to their availability and low cost. Filtration is one of the simplest and low cost treatment technology based on the principle of attached growth process. Multimedia filters represent a significant improvement over single media filters. A multimedia filter model was developed by plastic bottle for treatment of wastewater. Different packing media such as Activated carbon, Rice husk, and Sand are used. The wastewater samples were physically and chemically characterized before and after treatment according to standard procedure using these adsorbents. The obtained results after treatment shows an appreciable improvement on the quality of the water. The pH value changed upto 2.63%, the colour changed from soapy and cloudy to colourless, conductivity, turbidity was reduced upto12.43% and 85.70%, respectively, while the chemical oxygen demand (COD) was reduced upto 80%. The significant removal of suspended solids and dissolve solids was upto 47.06% and 47.88%, respectively. This study intense to provide an overall vision of multimedia filter technology an alternative of conventional method for treating wastewater. Treated wastewater can be reused for various purposes such as irrigation, toilet flushing, car washing, gardening, firefighting, etc.

***Keywords:*** *Wastewater, Adsorbents, Multimedia filter, Activated carbon, Rice husk.*

## 1. INTRODUCTION

Nowadays, water pollution is one of the major problems in the world. In Bangladesh, major problem leading to water pollution is increasing population, industrialization and urbanization (Hasan et.al., 2019). Collection, treatment and disposal of domestic and industrial wastewater are the significant issues to be handled for preventing damage to the environment. Discharge of untreated sewage is the most important reason for pollution of surface and ground water in Bangladesh. Besides that, the purpose of wastewater treatment is to remove pollutants that can harm the aquatic environment if they are discharged into it. Wastewater generated in urban areas normally treated in the treatment plant includes the processes like primary sedimentation, aeration, secondary treatment and chlorination. The arrangement for this treatment plants requires high cost and large land area. About 50 percent of used water is being lost each year (US EPA, 2018).

Water is a vital part of environment which is polluted by indiscriminate dumping of Municipal wastewater in the natural water bodies. To dispose this huge daily produced wastewater safely into the environment, an affordable technology should be introduced. Again for irrigation, large amount of water is pumped throughout the year which continuously lowering the ground water table. So to satisfy the environmental condition and economic restraints, low cost natural adsorbent filter media is used to treat the wastewater. This treated water is testified to checks weather it can be used for irrigation water resources or not.

Wastewater treatment may include mechanical, biological, and physical-chemical methods (Crini&Lichtfouse,2019). Selection of suitable treatment method depends on the types of pollutant available in raw wastewater. One wastewater treatment using physiochemical methods is adsorption, which has the advantages of being fast, cheap, and universal for removing organic pollutants from water. For removing variety of pollutants from water, different low-cost materials are used as adsorbents, including agricultural products, industrial wastes, and activated carbon.

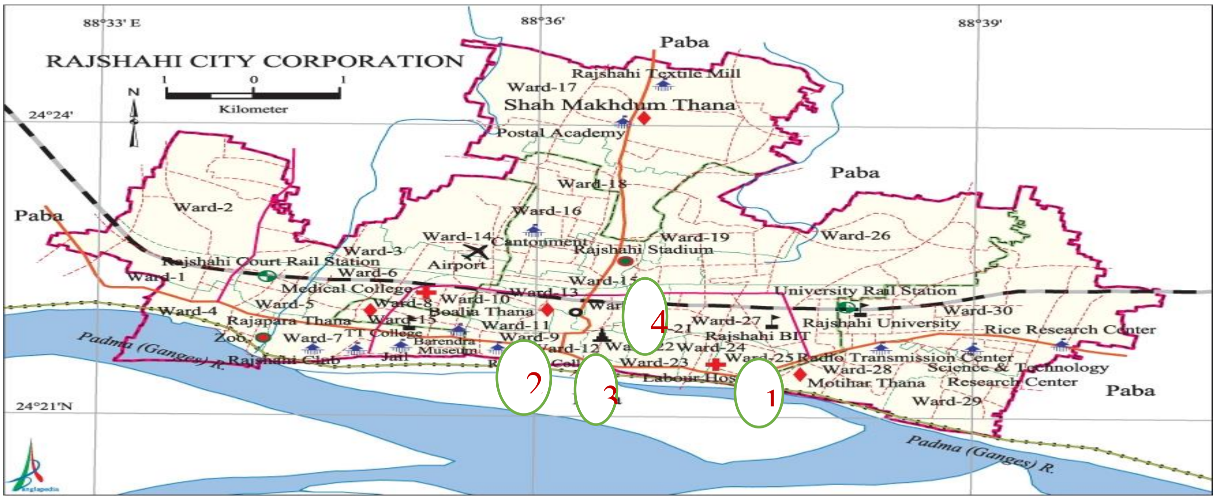
Filtration is one of the oldest and simplest methods of removing contaminants. Generally, filtration methods is known as sand filtration. Sand filtration is suitable for low turbidity and suspended solid of water. But for water contain high turbidity and suspended solid, multimedia filtration is more suitable. For characterization of municipal wastewater, many researchers had done their experiment on wastewater. For example, Sagara (2000) has done a recharge on filtration for point of use drinking water treatment in Nepal. His research was focused on turbidity and microbial removal efficiencies. For this treatment, he has used three filter or purification systems such as Nepalese ceramic candle filter and IPI purifier (Junko Sagara, 2000). His research showed that the turbidity removal efficiency of multifilter media was very high. Priyadarsini (2013) has conducted a study on development of low cost water purification technique. In this study, the turbidity and iron of wastewater were characterized and different materials were used to purify the wastewater to find the low cost water purification technique (Priyadarsini, 2013). The removal of iron content was 5.785 to 0.299 ppm and turbidity was 13.5 to 5.3 when ceramic filter was used. She also used activated carbon, wood charcoal, plain sand and ash of banana leaf as adsorbent for making the filter unit. Ratnoji and Singh (2014) have done a research on coconut shell- activated carbon for filtration and its comparison with sand filtration. They have done this research on the reduction and removal of iron, turbidity, biochemical oxygen demand (BOD) (Ratnoji & Singh, 2014). Shilpa S. Ratnoji and Nimisha singh used coconut shell and activated carbon as adsorbent and removal efficiency of COD was found 53%. Mathias Osterdahl (2015) has done a research on slow sand filters purification rates in rural areas in Colombia. In this study, the characteristics such as alkalinity, color, pH, turbidity, nitrate, nitrite, phosphate, coliforms and Escherichia coli are analyzed (Osterdahl, 2015). Study result shows that, the percentages removal of turbidity, color, alkalinity, nitrite, nitrate, phosphate were 86%, 0%, +2.8%, 0%, 0%, and 72% respectively. Grace et. al. (2016) has done a research on development of filtration technologies for an alternative filtration configuration, harnessing the adsorption potential of industrial waste products and natural media. The study was focused on the variety of contaminants such as aluminium, ammonium, nitrate, turbidity and total organic carbon (TOC), (Graceet. al., 2016). This study developed an effective, cost efficient and robust filtration technologies for water treatment, where the percentage removal of aluminium, TOC and ammonium was about 97%, 71% and 88%. Emara, et. al. (2016) have done a research on phsico-chemical studies for boiler water treatment and its impact on the quality of final industrial product. In this study, wastewater was characterized on turbidity, hardness, total dissolved solid, alkalinity, organic matters, silica and pH (Emara, et al., 2016). The study result shows the removal of turbidity, hardness, total dissolved solid, alkalinity, organic matters and silica was 0.72 to 0, 164 to 0, 396 to 20, 146 to 22.3, 2 to 0, and 7.5 to 1.5 respectively. The removal efficiency for the used multimedia filter is upto 85.70% for turbidity, 80% for COD and 68.75% for organic content which can be considered as advance removal efficiency as used filter media was made of sand, activated carbon and rice husk which layer thickness was too much small.

The above studies showed significant performances of granular media as adsorbent materials in filtration technology. However, the performance of multimedia filter is much better than filter unit containing single filter media. In addition, a few studies was conducted to evaluate the efficiency of multimedia systems which can be improved by optimizing the process parameters such as filter media types, contact time, wastewater loading rate etc. Hence, the main objective of this study is to design the low-cost multimedia filter model using low-cost natural adsorbents so that most of the pollutants can be removed from wastewater. The multimedia filter is also cost effective and environment friendly which can be easily constructed and implemented for wastewater treatment. The multimedia filtration system can be integrated with wastewater treatment plant for removal of objectionable pollutants. Treated wastewater can be reused for various purposes such as irrigation, toilet flushing, car washing, gardening, firefighting, etc.

## 2. METHODOLOGY

### 2.1 Study Area Selection

The study area was selected at four different locations in Rajshahi City. These locations are Fultola Drain, Dorgapara Drain, Padma Garden Drain and Shuvo petrol Pump Drain as shown in Figure 1. The source of wastewater in these drains are mainly storm water runoff from road surfaces.




Fultola[1] Dorgapara[2] Padma Garden[3] Shuvo Petrol Pump[4]

Figure 1: Locations of study site.

### 2.2 Sample Collection and Preservation

Wastewater samples were collected from selected four drains. The sample collection was carried out about eight weeks between the periods of April-May in the year of 2019.At each location, random sample collection frequency was five times. Accordingly, a total of 20 samples were collected from four drains within eight weeks. The wastewater samples were collected according to the EPA (1992) guideline. The collected sample details such as time, date, location were properly leveled for future identification. The samples were kept in a refrigerator at a temperature of 0-4°C to conduct the filtration, physical and chemical parameters test.

### 2.3 Laboratory Testing

The physical parameters such as pH, Electrical conductivity, turbidity etc. were tested instantly in the Environmental Engineering laboratory, RUET to get the accurate results at room temperature. The chemical parameters such as COD, Acidity, etc. were also measured in the laboratory.

### 2.4 Design and Construction of the Multimedia Filtration System

#### 2.4.1 Materials

The multimedia filtration system was designed and constructed using following materials.

1. Plastic bottle is used as filter's unit body. The length of the bottle was 25 cm containing top diameter of 7.5 cm, middle diameter of 6 cm and bottom diameter of 7.5 cm.

2. Absorbent media's

- Fine sand for screening purpose
- Rice husk
- Activated carbon

The three types of filter media's are shown in Figure 2.The size of the filter media's varies from 0.1 mm to 1.4 mm.

a b c

Figure 2: Filter media's (a) Rice Husk (b) Activated Carbon (c) Sand

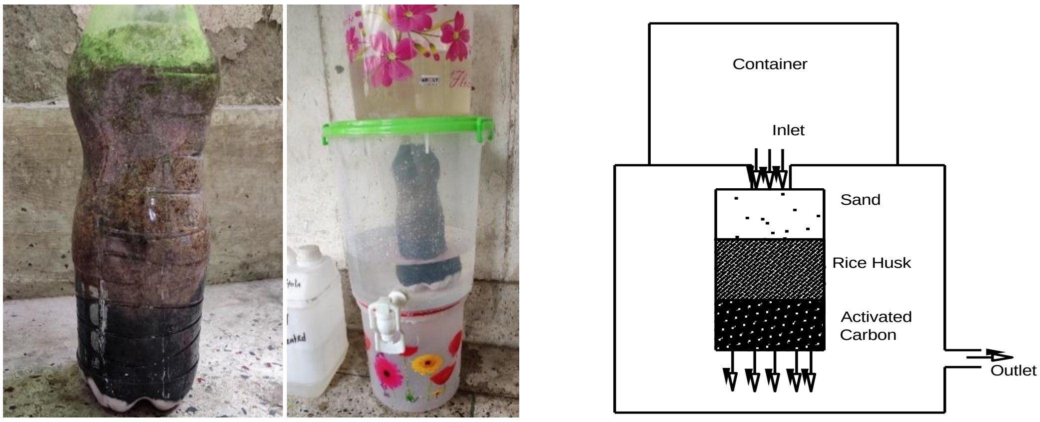
#### 2.4.2 Construction Procedure

The lab scale multimedia filtration system was constructed, using a 1000mL plastic bottle. The cork and bottom of the bottle was drilled to a diameter of 2.2mm. Then filtration materials were placed into three different layers and each layer thickness was 80 mm. These three layers are arranged and placed in order as follows:

1. The first layer was fine sand. The size of the fine sand varies from 0.8 to 1.1 mm and layer thickness was 80 mm.
2. Rice husk is the second layer that is placed below the fine sand. The size of rice husk varies from 0.1 to 1.4 mm and the thickness of the layer is 80 mm.
3. Activated carbon is the last layer and placed at the bottom of the bottle below the rice husk layer. The thickness of rice husk is 80 mm.

For the protection of filtering media from drain out during filtration, a 25mm thickness of cotton was used after the activated carbon layer of the bottle.

The filtration system and arrangement of filter media's are presented in Figure 3.




**(a)** **(b)** **(c)**

Figure 3: (a) Arrangement of filter media (b) filtration system (c) Line diagram of laboratory arrangement

## 3. RESULTS AND DISCUSSION

The selected adsorbent media's such as sand, rice husk and activated carbon was found to be more effective in improving the physical and chemical parameters of wastewater (Bryant et. al., 2015). This filter media also assist in removing of COD, TSS, TDS,OC, EC, turbidity and also improve pH quality of the treatment water. Hence, these results prove that adsorbent filter media can be more efficient in removing of impurities and make the water suitable for natural discharge and irrigation purposes. The collected samples were filtered through multimedia filtration system and tested in the Laboratory. The test results for various water quality parameters are presented in Tables 1-7 and Figures 4-10. The details investigation about specific parameters are explained in the following sections. Maximum permissible limit (MPL) for both natural discharge and irrigation was compared according to Indian standard IS: 2490, part-I-1981.

### 3.1 pH

The term pH refers to the measure of hydrogen ion concentration in a solution and defined as the negative log of $H^+$ ions concentration in a water and wastewater. The values of $p^H$ ranges from 0 to a little less than 7 are termed as acidic and the values of $p^H$ a little above 7 to 14 are termed as base. When the concentration of $H^+$ ions and $OH^-$ ions are equal then it is termed as neutral $p^H$. The tolerable limit is varying from 5.5 to 9.0. The value of pH was measured by the Multi-parameter analyzer (DZB-718). The results are shown in the Table 1 and variations at different study locations are presented in Figure 4. As seen in Figure 4, the multimedia filtration system are capable of removing pH value upto 2.63%. The pH value for all study locations were found within the permissible limit required for irrigation and safe disposal (Table 1).

Table 1: $P^H$ value of municipal wastewater of Rajshahi City

| Location | $P^H$ before treatment | $P^H$ after treatment | % of removal | MPL for irrigation | MPL for discharge |
|---|---|---|---|---|---|
| Fultota | 7.28 | 7.10 | 2.47 | 5.5-9.0 | 5.5-9.0 |
| Dorgapara | 6.85 | 6.70 | 2.18 | 5.5-9.0 | 5.5-9.0 |
| Padma garden | 6.98 | 6.80 | 2.57 | 5.5-9.0 | 5.5-9.0 |
| ShuvoPetrol pump | 7.20 | 7.01 | 2.63 | 5.5-9.0 | 5.5-9.0 |

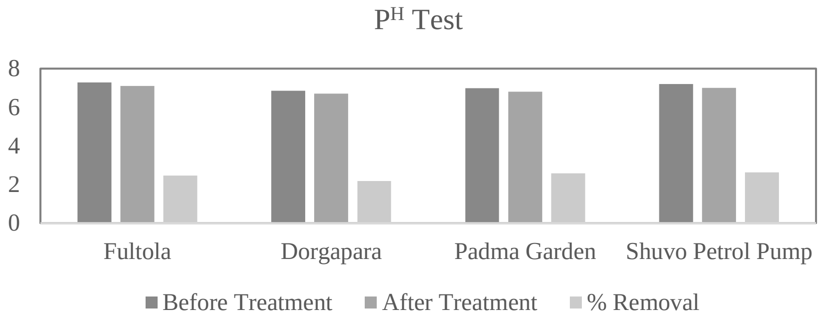



Figure 4: Variation of pH and % removal at study locations

### 3.2 Conductivity

Conductivity of a substance is defined as 'the ability or power to conduct or transmit heat, electricity or sound'. When an electrical potential difference is placed across a conductor, its movable charges flow, the substances are giving rise to an electric current. The maximum permissible limit of conductivity is 2250 µmhoes/cm. The value of Conductivity was measured by the Multi-parameter analyzer (DZB-718). The results are shown in Table 2 and graphically presented in Figure 5. As seen in Figure 5, the multimedia filtration system are capable of removing conductivity value upto 12.43%. The conductivity value for all study locations were found within the permissible limit required for irrigation and safe disposal (Table 2).

Table 2: Conductivity values of municipal wastewater of Rajshahi City.

| **Location** | **Before treatment** | **After treatment** | **% of Removal** | **MLP for irrigation** | **MPL for discharge** |
|---|---|---|---|---|---|
| Fultota | 2200 | 1950 | 11.36 | 2250 | 2250 |
| Dorgapara | 1900 | 1750 | 7.7 | 2250 | 2250 |
| Padma garden | 1850 | 1620 | 12.43 | 2250 | 2250 |
| Shuvo Petrol pump | 2000 | 1800 | 10 | 2250 | 2250 |

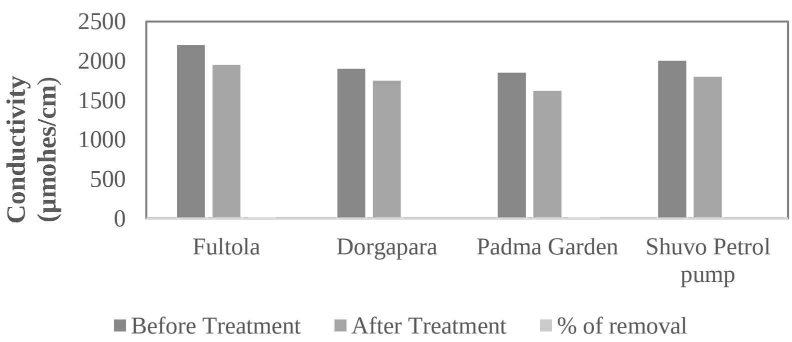



Figure 5: Variation of turbidity and % removal at study locations

### 3.3 Turbidity

Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. The maximum permissible limit for turbidity is 35 NTU. The value of pH was measured by the Turbidimeter (TN-100). Figure 6 shows that the multimedia filtration system is capable of removing turbidity value upto 85.70%. The turbidity value for all study locations were found within the permissible limit required for irrigation and safe disposal (Table 3).

Table 3: Turbidity values of municipal wastewater of Rajshahi City

| **Location** | **Before treatment** | **After treatment** | **% of Removal** | **MPL for irrigation** | **MPL for discharge** |
|---|---|---|---|---|---|
| Fultota | 27.1 | 5.17 | 80.92 | 35 | 35 |
| Dorgapara | 15.60 | 2.23 | 85.70 | 35 | 35 |
| Padma garden | 17.73 | 3.01 | 83.02 | 35 | 35 |
| Shuvo Petrol pump | 27.02 | 4.14 | 84.67 | 35 | 35 |

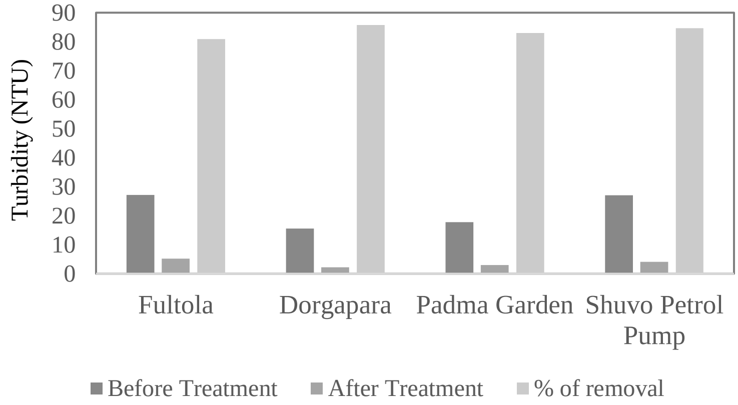



Figure 6: Variation of turbidity and % removal at study locations

### 3.4 COD

The Chemical Oxygen Demand (COD) method determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature, and time. It is measured in mg/L. The results for COD are shown in the Table 4 and graphically presented in Figure 7.As seen in Figure 7, the multimedia filtration system is capable of removing COD value upto 80%.

Table 4: COD values of municipal wastewater of Rajshahi City

| **Location** | **Before treatment** | **After treatment** | **% of Removal** |
|---|---|---|---|
| Fultola | 5.9 | 3 | 49.15 |
| Dorgapara | 14 | 7.7 | 45 |
| Padma Garden | 13.6 | 6.9 | 49.26 |
| Shuvo petrol pump | 5 | 1 | 80 |

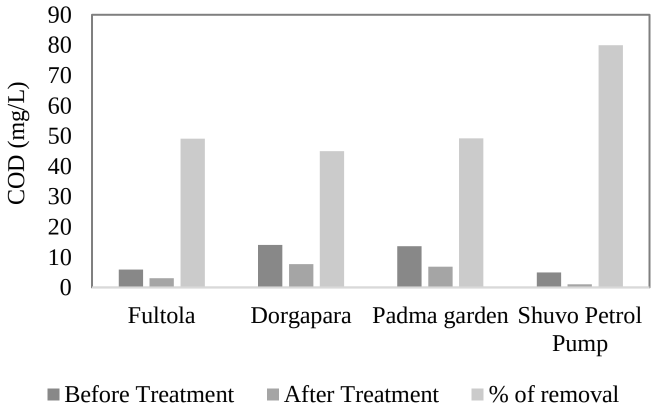



Figure 7: Variation of COD and % removal at study locations

### 3.5 Total Suspended Solid and Total Dissolved Solid

Total solid is the term applied to the material residue left in the vessel after evaporation of the sample. Total suspended solids (TSS) give a measure of the turbidity of the water. Total dissolved solid (TDS) is nothing but the dissolved in organic impurities present in the sample, it is calculated by subtracting the total suspended solid from total solid. The maximum permissible limit of total suspended solid (TSS) is 100 mg/L for direct discharge into natural water bodies and 200 mg/l for use in irrigation (IS: 2490, part-I-1981). The maximum permissible limit of Total Dissolved Solid (TDS) is 2000mg/l. The results for TDS and TSS are shown in the Tables 5-6 and Figures 8-9.As seen in Figures 8-9, the multimedia filtration system is capable of removing TDS and TSS value upto 47.88% and 47.06% respectively. The TDS and TSS value for all study locations were found within the permissible limit required for irrigation and safe disposal (Table 5-6).

Table 5: Values of Total Dissolved Solid (TDS) municipal wastewater of Rajshahi City

| **Location** | **Before treatment** | **After treatment** | **% of Removal** | **MPL for irrigation** | **MPL for discharge** |
|---|---|---|---|---|---|
| Fultota | 740 | 425 | 42.56 | 2000 | 2000 |
| Dorgapara | 670 | 350 | 47.76 | 2000 | 2000 |
| Padma garden | 710 | 370 | 47.88 | 2000 | 2000 |
| Shuvo Petrol pump | 510 | 390 | 23.53 | 2000 | 2000 |

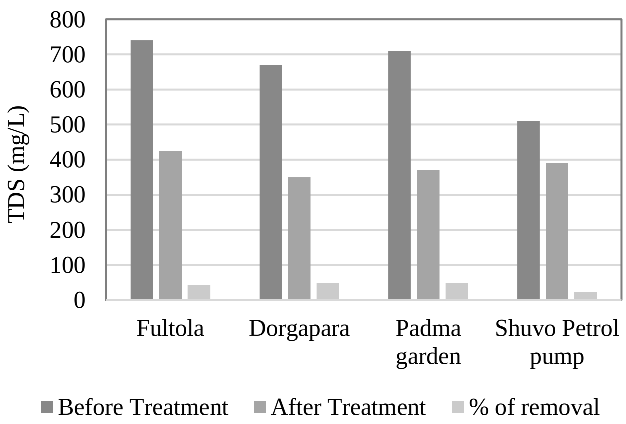



Figure 8: Variation of TDS and % removal at study locations

Table 6: Values of Total Suspended Solid of municipal wastewater of Rajshahi City

| **Location** | **Before treatment** | **After treatment** | **% of Removal** | **MPL for irrigation** | **MPL for discharge** |
|---|---|---|---|---|---|
| Fultola | 160 | 85 | 46.87 | 200 | 100 |
| Dorgapara | 170 | 90 | 47.06 | 200 | 100 |
| Padma Garden | 140 | 80 | 42.85 | 200 | 100 |
| Shuvo Petrol pump | 240 | 140 | 41.67 | 200 | 100 |

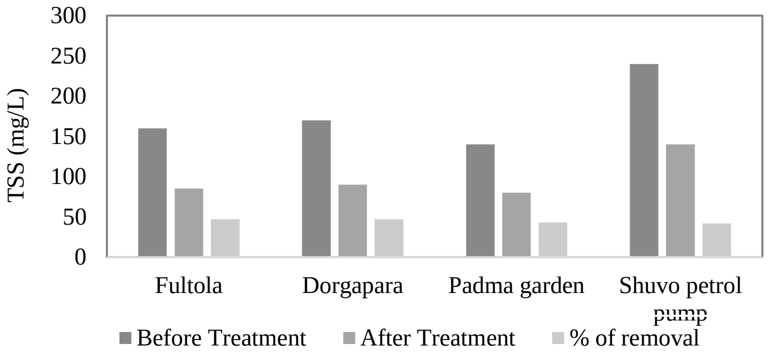



Figure 9: Variation of TSS and % removal at study locations

### 3.6 Organic Content

Organic content refers to the large pool or carbon-based compounds found within natural and engineered, terrestrial and aquatic environment. It is matter composed or organic compounds that has come from the remains of organisms such as plants and animals and their waste products in the environment. The maximum permissible limit of total organic content is 250 mg/l for natural discharge and 200 mg/l for irrigation. The results obtained are shown in the Table 7 and graphically presented in Figure 10. As seen in Figure 10, the multimedia filtration system is capable of removing organic content value upto68.75%. The organic content value for all study locations were found higher than maximum permissible limit. However, after filtration organic content have reached within the permissible limit required for irrigation and safe disposal (Table 7).

Table 7: Total Organic Content values of municipal wastewater of Rajshahi City

| **Location** | **Before treatment** | **After treatment** | **% of Removal** | **MPL for irrigation** | **MPL for discharge** |
|---|---|---|---|---|---|
| Fultola | 800 | 250 | 68.75 | 200 | 250 |
| Dorgapara | 640 | 223 | 65.15 | 200 | 250 |
| Padma Garden | 530 | 195 | 63.20 | 200 | 250 |
| Shuvo petrol pump | 405 | 156 | 61.48 | 200 | 250 |

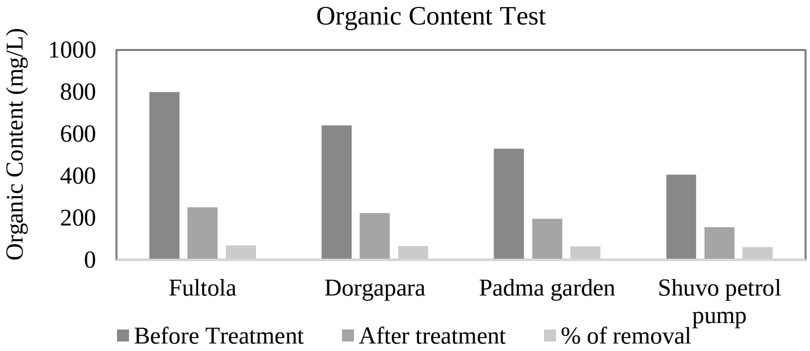



Figure 10**:** Variation of organic content and % removal at study locations

## 4. MATHEMATICAL EQUATION

$$Q=AV \quad (1)$$

Where, Q= Discharge water, A= Cross sectional area. V= Velocity of water

Here, cross sectional area was A=26.1 $mm^2$ and Q= 0.4 l/hr, Then discharging velocity, V=15.032 m/hr

## 5. CONCLUSION

The wastewater of Rajshahi city contains high amount of organic content. However, multimedia filtration system removed successfully up to 68.75% organic content from wastewater and returned within the permissible limit. In addition, the filtration system was found very effective for removing COD value upto 80%.

The multimedia filtration system removed total suspended solid and total dissolved solid from wastewater up to 47.06% and 47.88% respectively and meets with discharge water quality standards. All other parameters such as pH, turbidity and conductivity were found under permissible limit and don’t bear any harmful effect.

Based on the study results, it can be concluded that the developed multimedia filtration system is very effective for reducing variety of pollutants concentration from wastewater. Treated wastewater can be reused for various purposes such as irrigation, toilet flushing, car washing, gardening, firefighting, etc.

## ACKNOWLEDGEMENTS

The author would like to acknowledge Dr. Anupam Chowdhury and Dr. Md. Kumruzzaman (1), Department of Civil Engineering, Rajshahi University of Engineering & Technology, Bangladesh for their valuable guidance, encouragement and tremendous support.

## REFERENCES

Crini, G., & Lichtfouse, E. (2019), Advantages and disadvantages of techniques used for wastewater treatment. Environmental Chemistry Letters, *Springer Verlag*, 2019, 17 (1), pp.145-155.

Indian Standard Drinking water specification: 2490, part-I-1981

Sagara, J. (2000). Study of Filtration for point of use drinking water treatment in Nepal. Massachusetts Institute of technology, 2000.

Priyadarsini, L., (2013). Development of low cost water Purification Technique. Rourkela, 2013.

Osterdahl, M. (2015). An inventorying study of slow sand filters purification rates in rural areas in Colombia. Colombia, 2015, pp-43.

Grace, M. A., Healy, M. G., & Clifford, E. (2016). Performance and surface clogging in intermittently loaded and slow sand filters containing novel media. *Journal of Environmental Management 180 (2016), 102-110.*

Hasan, M. K., Shahriar, A., & Jim, K. U., (2019), Water pollution in Bangladesh and its impact on public health. *Heliyon*, 2019, 5, e02145

Emara, M. M., AbdElaziz, F., & Elbarbary, Y. H., (2016). Physico-Chemical Studies for boiler Water treatment and its impact on the Quality of final industrial Product. *International Journal of Scientific and Research Publications, 2016, volume-6.*

Ratnoji, S. S., & Singh N. (2014). A study of coconut shell-activated carbon for filtration and its comparison with sand filtration.*International Journal of Renewable Energy and Environmental Engineering ISSN 2348-0157, Vol. 02, No. 03.*,2014, pp.1-4.

Statistics and Facts, Water sense US EPA, 2018, Retrieved from http://www.epa.gov/watersense/statistics-and-fact